PEARL

The Journal of HEREDITY

DIPLOID AND TETRAPLOID CEDUM PLANTS
(SEE PAGE 241)

Genetic Background of Successful Tissue Grafts
Two Inherited Tooth Defects in One Family
The "Market Test" of Eugenic Fitness
The "Satin" Rabbit—A New Mutation
Haploid Cotton Plants

VOLUME 27 JUNE, 1936 NUMBER 6

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The

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Vol. XXVII JUNE, 1936 No. 6

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Maps of Salivary Chromosomes

MAPS of the giant salivary chromosomes form the groundwork for much new research and are of great value as instructional material as well. The two maps published in the JOURNAL (in the December, 1934, and February, 1935, issues) are offered, unfolded, on heavy paper for mounting or framing, at the following prices:

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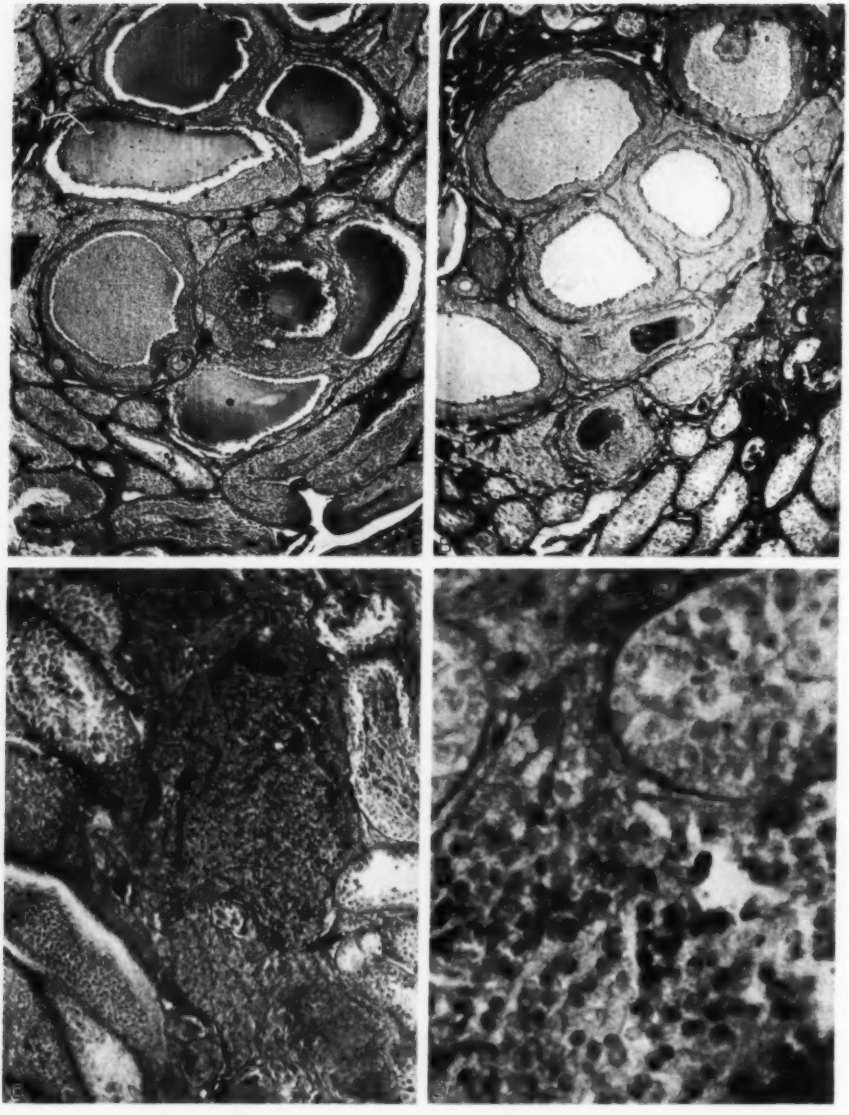

SUCCESSFUL TISSUE GRAFTS IN RELATED INDIVIDUALS

Frontispiece

Photomicrographs (*A*, *B*, 60×; *C*, *D*, 125×) showing grafts made into the testes of F_1 males of a cross between two inbred lines of mice, designated *N* and *CBA*. Grafts between these two strains consistently failed to grow, but grafts in which the F_1 hybrid males were the hosts were successful, demonstrating that the genetic background is a vital factor in successful tissue transplatation. *A* shows an ovarian graft from an *N* female growing in the testis of an F_1 male (Mouse 114). The circular objects are sections through primary and secondary ovarian follicles, showing that the grafts are growing actively. *B* shows a similar graft made from an F_1 female into an F_1 male (Mouse 113). *C* shows a graft of pituitary gland tissue from an F_1 female growing in the testis of an F_1 male (Mouse 119). *D* shows a similar graft from a *CBA* female growing in an F_1 male (Mouse 123). The physiological activity of the ovarian graft is demonstrated in Figure 1. Tissue grafts made between individuals of the *N* and *CBA* strains were uniformly negative, whereas grafts between the hybrids of the two strains and between the hybrid and the parent strains are successful in a large proportion of cases.

GENETICS OF PITUITARY AND OVARY GRAFTS

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THE pituitary has recently been successfully grafted by several investigators. Hohlweg and Junkmann[6] recovered pituitary tissue one month after it had been grafted into the kidneys of rats. The testes were used as the site of grafts in mice (Gardner and Hill[3]). Haterius, Schweizer and Charipper[5] found that homeoplastic transplants persisted in the anterior chamber of the eye of rabbits and guinea pigs for a period of at least four months. Early attempts to graft pituitary tissue in the dog had been unsuccessful.[2]

Ovarian grafts have been made into mice by at least two investigators (Tamura[13] and Gardner[4]). However, the guinea pig has been most frequently used for grafting experiments with ovaries.[10]

The extremely high percentage of persisting grafts observed by Gardner and Hill, when litter mates of closely inbred strains were used as hosts and donors, raised the question of the possible influence of the genetic uniformity of these hosts and donors upon the establishment of the grafted tissues. The successful transplantation of malignant tissues by Strong and Cloudman[12] and of the spleen and liver by Little and Johnson[7] and by Bittner[1] into the subcutaneous tissues have been shown to depend upon the genetic or intrinsic uniformity of the hosts and donors.

A study of the influence of hereditary factors upon the persistence of hypophyseal and ovarian grafts made into the testes has been made. The type of tissue and the location of the tissue in the host both vary from the tissues and the locations of the transplants previously studied on a genetic basis. Furthermore, the grafted ovarian tissues were physiologically active in the production of estrogenic substances. It has thus been possible to study the function as well as morphology of persisting ovarian tissues in the host testis.

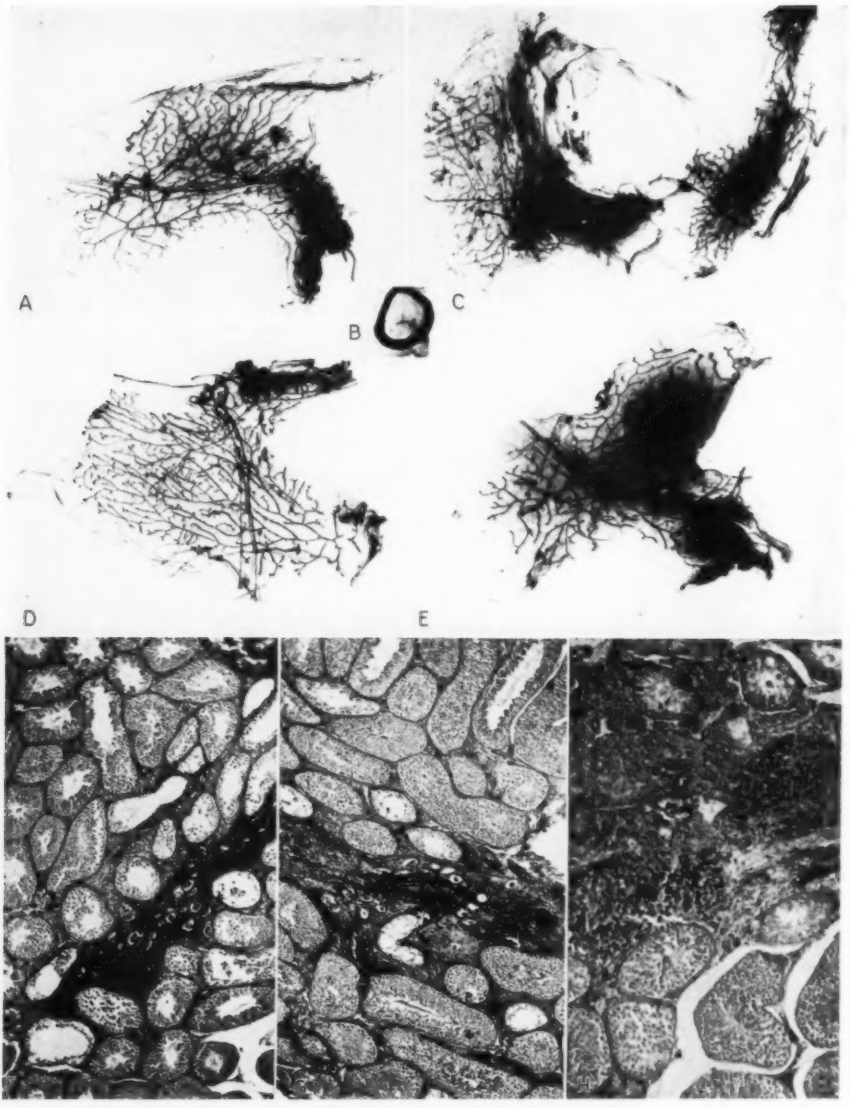
Materials and Technique

The mice used in this investigation were from seven inbred strains. Six of these (*A, CBA, N, L, JK,* and *CHI*) have been developed by the author, and one (*D*) was developed by Little. These strains have been inbred for from twenty-three to fifty-six generations.

The female mice used as donors were killed by decapitation and the pituitary and ovaries exposed while the male hosts were being prepared to receive them. The male hosts were anaesthetized with sodium amytal. The testes were exposed through a low mid-ventral incision. A small incision was made in the tunica and the grafts placed among the seminiferous tubules. The testes were then returned to the abdominal cavity and the muscle and skin incision sutured with silk.

The mice bearing the grafts were killed from 14 to 53 days after the operation. The mammary glands were fixed on the skins in Bouin's fluid. After fixation they were dissected from the skin and stained in Mayer's hemalum. If the mammary rudiments showed any evidence of proliferation they were de-

*This experiment has been made possible by grants from the Josiah Macy, Jr., Foundation and the International Cancer Research Foundation. The author also wishes to acknowledge the kindness of Dr. W. U. Gardner and Dr. R. T. Hill in aiding in the performance of this experiment.



PROOF OF ACTIVITY OF OVARY GRAFTS

Figure 1

A-E prove the physiological activity of the ovarian gland grafts (Frontispiece) by demonstrating a striking effect on the mammary glands of the male hosts. *B* shows a normal mammary gland rudiment of a *CBA* male 76 days old (3.6×). *A* and *C-E* show mammary glands (also 3.6×) of four male mice F_1 *N* × *CBA*) which carried successful grafts of ovarian tissue. *A* is a mammary gland from F_1 male 125 bearing an ovarian graft from a *CBA* female. *C* and *D* are similar preparations (F_1 male 113 and F_1 male 119) in which the donors were F_1 females. In *E* (F_1 male 114) the donor was an *N* female. Thus when females of both parental strains and of the F_1 were donors viable grafts were produced in F_1 males. *F* and *G show* unsuccessful grafts (60×) in which the male host was of the *N* strain and the donors were an F_1 female (*F*) and a *CBA* female (*G*). The necrotic ovarian tissue is represented in the dark area in each of these sections. *H* shows an F_1 testis (male 125) bearing a viable pituitary graft from an F_1 donor (125×).

hydrated, cleared, and mounted *in toto*. The testes were usually fixed in Zenker-formol solution, cut serially and stained with a modified Mallory's triple connective tissue stain.

Observations

A total of ten different interstrain combinations were used in establishing the strain specificity of the reaction of grafted tissues in the testes. Fifteen pairs of mice from seven different strains were used. The combinations were as follows: (1) *CBA* into *N;* (2) *N* into *CBA;* (3) *N* into *A;* (4) *L* into *JK;* (5) *CBA* into *A;* (6) *JK* into *L;* (7) *D* into *A;* (8) *A* into *JK;* (9) *A* into *L;* and (10) *A* into *CHI*. All these combinations except one of those in which the *A* mice were used as hosts gave consistently negative results. As several of the strains have descended from the Strong *A* strain, this fact is not antagonistic to a genetic interpretation. The combination in which the *CBA* and *N* were donors or hosts were uniformly negative. These two strains were therefore used in the following genetic study of the persistence and function of the pituitary and ovarian grafts.

Two separate phenomena were studied, namely, (1) the persistence of the grafts as well as organized tissues and (2) the physiological activity of the ovarian graft as indicated by the growth of the male mammary rudiments under the influence of the secretion from the ovarian grafts. Sufficient criteria for the determination of the physiological activity of the pituitary grafts were lacking in these mice under the conditions of the experiments.

The results obtained from grafting the pituitary and ovarian tissues using the mice from the *CBA* and *N* strains, and their F_1 hybrids as hosts and donors may be briefly summarized as follows:

(1) Male mice from the *CBA* strain all grew the grafts obtained from other mice of the *CBA* strain.

(2) Male mice from the *N* strain all grew the grafts obtained from other mice of the *N* strain.

Though the grafts involving the above intrastrain combinations were not summarized in Table I, a large amount of published and unpublished data has established the above statements (Gardner and Hill,[3] Gardner,[4] and Gardner and Hill, unpublished).

(3) The pituitary and ovarian grafts from female mice of the *CBA* strain did not grow in male mice of the *N* strain (3 cases).

(4) The pituitary and ovarian grafts from female mice of the *N* strain did not grow in male mice of the *CBA* strain (1 case).

(5) The F_1 individuals all grew the transplants obtained from mice of the *CBA* and *N* strains and of other F_1 mice (18 cases).

(6) Male mice from the *CBA* and the *N* strains did not grow the tissues obtained from the F_1 mice produced by crossing mice of the *CBA* and *N* strain (7 cases).

Discussion

The extensive studies which have been conducted on the transplantability of malignant tissues (Tyzzer, Little, Strong, Bittner and Cloudmann, see Strong[11]) have definitely shown that the mechanism determining the persistence of such grafts is inherited as a multiple factor complex. This complex is transmitted as a dominant. The limited data obtained from the above experiments with ovarian and pituitary grafts show complete agreement with the above facts though the number of genetic factors involved remains unknown.

Two points should be emphasized in connection with the present observations: first, the above grafts were made into the testes whereas other grafted tissues studied from a genetic standpoint have all been made subcutaneously, and second, the endocrine glands grafted in the present investigation exert certain reciprocal physiological influences upon one another and upon the host and the host's homologous glands. The endocrine inter-relationships will not be discussed in the present paper as they have

not been well established in the mouse. Smelser[10] has discussed these relationships in the guinea pig.

The ovarian grafts were physiologically active in the animals in which they were established. Actively growing primary and secondary follicles were present. The mammary gland rudiments (Figure 1*B*) had undergone extensive development (Figure 1*A,C,D,E*). The type and extent of mammary gland growth resembles that induced by estrogenic hormones or that observed in virgin female mice (Gardner[4]).

The persistent pituitary grafts made into the anterior chamber of the eye using unrelated animals do not necessarily indicate the absence of tissue specificity. Such grafts do not establish vascular connections. Connective tissue reactions of the host tissue are apparently minimal, and the aqueous humour is a good nutritive medium. It is therefore probable that the factors influencing successful grafting may be maximal under such conditions.

There is evidence that the persistence of grafts of some endocrine glands is

TABLE I. Composite data of grafts.

Host No.	Host stock	Donor stock	Days of age at grafting Donor	Host	Age of graft. Days	Condition mammary gland	Condition of graft Pit	ovary	Remarks
43	N	CBA	35	31	27	—	—	— —	
44	N	CBA	30	38	38	—	—	— —	
117	N	CBA	51	51	51	—	—	— —	
50	A	CBA	39	37	14	+	+ *	+ + *	
52	A	CBA	42	37	26	+ —	—	— —	
45	CBA	N	31	35	36	—	—	— —	
46	A	N	42	35	14	+	—	— —	
58	JK	A	53	52	37	—	—	— —	
59	L	A	52	52	37	—	—	— —	
60	CHI	A	40	45	30	—	—	— —	
61	CHI	A	40	45	39	—	—	— —	
49	JK	L	53	52	26	—	—	— —	
53	L	JK	52	53	20	—	—	— —	
55	A	D	42	42	37	+ —	—	— —	
57	L	JK	52	53	37	—	—	— —	
51	N	CBAN	29	30	21	—	—	— —	
115	N	CBAN	41	37	51	—	—	— —	
136	N	CBAN	67	43	29	—	—	— —	
137	N	CBAN	67	43	29	—	—	— —	
138	N	CBAN	67	43	29	—	—	— —	
139	N	CBAN	67	43	29	—	—	— —	
107	CBA	CBAN	36	40	32	+ —	—	— —	
54	CBAN	N	30	29	26	+ +	+	+ —	(one testis necrotic)
114	CBAN	N	37	41	53	+ +	+	+ +	
121	CBAN	N	29	53	48	+ +	+	+ +	
132	CBAN	N	43	68	30	+	+	+ +	
133	CBAN	N	43	68	30	+ +	+	+ +	
134	CBAN	N	43	68	30	+	+	+ +	
135	CBAN	N	43	68	30	+ —	+	+ +	
140	CBAN	N	43	68	30	+ +	+	+ +	
56	CBAN	CBA	30	37	37	+ +	+	+ +	
105	CBAN	CBA	40	36	31	+ +	+	+ +	
106	CBAN	CBA	40	36	32	+ +	+	+ +	
122	CBAN	CBA	29	53	48	+ +	+	+ +	
123	CBAN	CBA	29	53	48	+ +	+	+ +	
113	CBAN	CBAN	37	37	51	+ +	+	+ +	
116	CBAN	CBAN	27	27	52	+ +	+	+ +	
118	CBAN	CBAN	29	29	47	+ +	+	+ +	
119	CBAN	CBAN	29	29	47	+ +	+	+ +	
120	CBAN	CBAN	29	29	47	+ +	+	+ +	

Note:—Under mammary glands, — means no growth; + — slight growth; + definite growth; + + about ½ grown. Under condition of graft, + means persistence and — means no growth covering the condition of the pituitary and an ovary in each testis.

* These grafts are positive, but the cells are not normal.

increased when the host is deficient in the specific hormone produced by these grafts (May,[9] Loeb[8]). That is, the normal gland in the host is antagonistic to the establishment of a homologous grafted gland. This is not true for ovarian and hypophyseal tissues when they are implanted in the mouse testis (Hill and Gardner, unpublished). The possible effects of experimental ablation of an endrocrine gland, thus giving a state of complete deficiency, upon the successful "take" of a homologous implant from another strain is beyond the scope of the present paper.

Conclusions

1. The mechanism that controls the persistence of pituitary and ovary grafts into the testes of mice is inherited as a dominant.

2. The number of mendelian factors involved in this mechanism is, as yet, undetermined.

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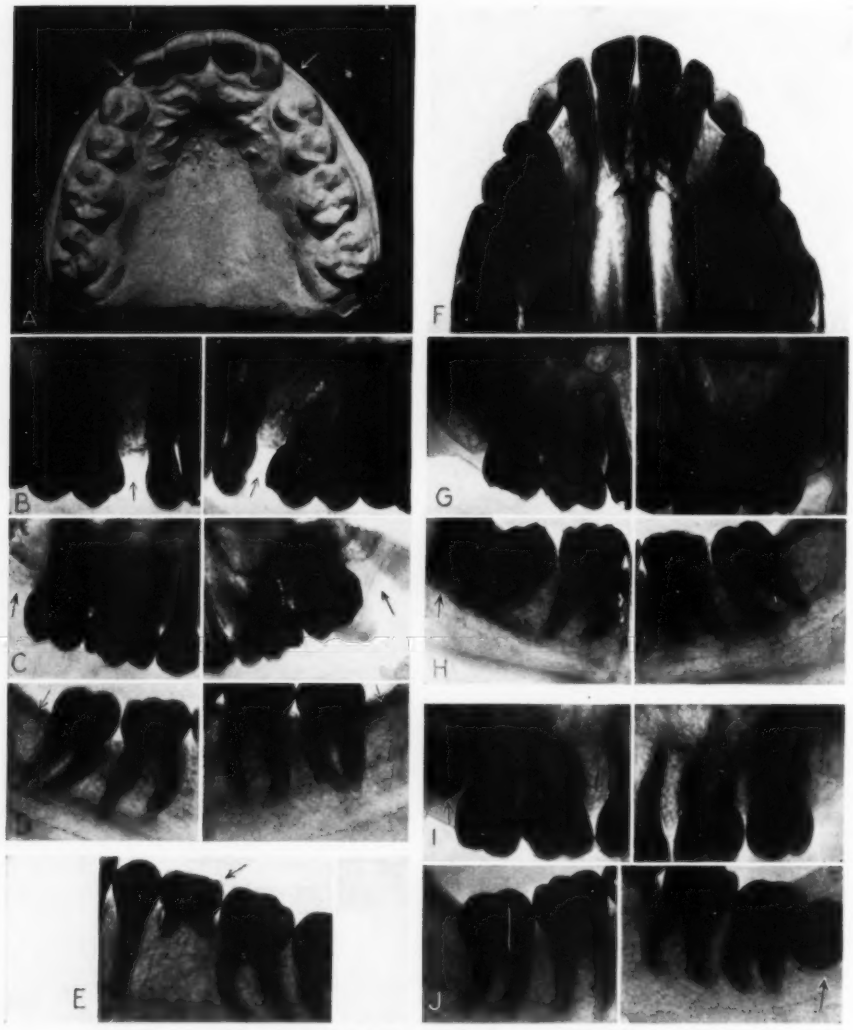
A Journal "Eugenics Bibliography"

IN response to the many requests for articles on human heredity in the Journal a complete list of all articles in the 26 volumes of the Journal has been prepared. This list comprises nearly 700 original contributions on human genetics, eugenics, twinning, effects of heredity and environment on human development, etc. The articles contained in this list give a fairly complete history of thought regarding eugenics since 1910. Many of them represent the actual factual building blocks on which rest our present knowledge of human genetics. The list is a mimeographed leaflet of seven pages. A copy may be had on application by members of the Association.



TOOTH DEFECTS IN GENERATION III

Figure 2

Cast and X-ray photographs of children of II-2 and II-3 showing combinations of tooth defects inherited from each parent. *A-D* show a cast of the upper jaw and X-ray photographs of the jaws of III-6. The cast shows the absence of canines and the wisdom teeth. *B* shows X-ray photographs of the upper jaw of this individual, showing that there is no trace of the permanent canine teeth. *C* and *D* show X-ray photographs of the wisdom tooth regions of this girl, showing that all wisdom teeth are completely missing. The arrows show the regions in which the wisdom teeth should appear. *F-H* are X-ray photographs of the jaws of III-7, showing the absence of permanent upper canines and wisdom teeth in this individual. These characteristics are inherited from her two parents. *F* is the X-ray photograph of the upper jaw where the patient is wearing porcelain pin teeth to cover the gaps of the missing canines, of which no vestige is present. *G-H* represent the wisdom tooth regions of this individual with the left lower wisdom tooth present and all others missing. In the right upper jaw the second deciduous molar has persisted and the corresponding premolar is absent. *I-J* show the wisdom tooth regions of III-8. The left upper and right lower wisdom teeth are present; the others are missing. *E* shows that the same boy has in addition a persistent second deciduous molar with no permanent tooth in the jaw to replace it.

TWO INDEPENDENT INHERITED TOOTH ANOMALIES IN ONE FAMILY

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HEREDITARY tooth reductions can be grouped in two classes. In some cases, tooth anomalies (often associated with defects of other epithelial organs, as hair, nails, etc.) are of an unsystematic character, and all groups of teeth may be affected rather irregularly in the same individual or family. Literature on cases in this class is to be found, for example, in Korkhaus' paper[3] and as an illustration we may cite the "toothless man of Sind" mentioned by Charles Darwin, and recently described again by Thadani[4].

While this type of anomaly is probably of little phylogenetic value, tooth reductions coming under the second classification are of a more systematic character. Here one particular group of teeth is suppressed, undoubtedly by gene action, while the rest of the set is usually not at all affected. Examples of this kind are the well known lack of the lateral upper incisors and a case of lack of the medium lower incisors described by Pitts[3]. In such cases, the germ of the permanent tooth is missing, with that of the deciduous tooth present, or the tooth germ may be lacking completely.

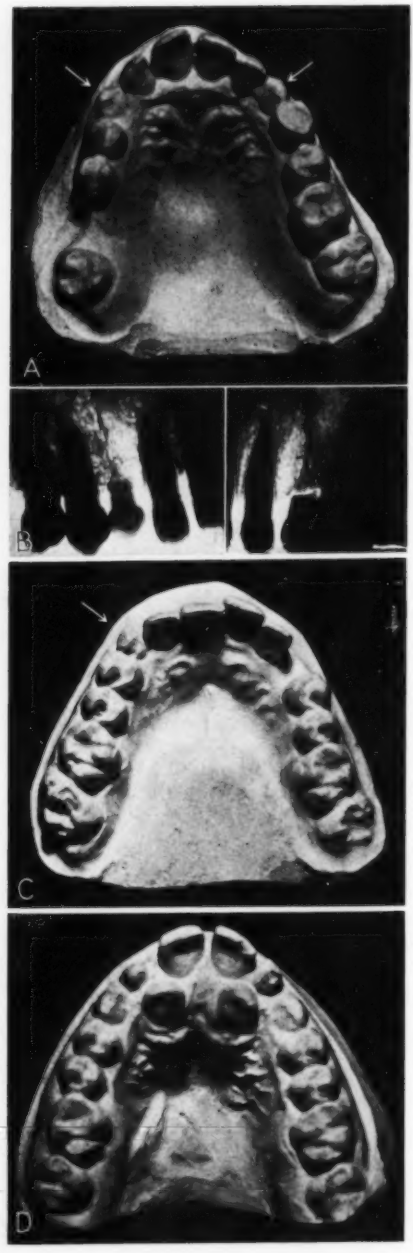
In any such case, where inspection of the mouth shows the lack of a tooth, it is indispensable to make sure by means of X-ray photographs that the lacking tooth is not retained or impacted in the jaws. Retention of teeth is a phenomenon wholly different from actual reduction. It may be mentioned that a case of complete retention of all the teeth caused by a recessive factor, has recently been described by the author in the house mouse[1,2].

In this paper, a pedigree of German Jews will be described. It is remarkable for the fact that two independent tooth reductions coming from different sources occur in one and the same family. Neither anomaly has yet been described as an hereditary condition. One of them concerns the lack of the permanent upper canines. One man of this family married a woman with anomalies of the wisdom teeth. The whole pedigree is given in Figure 4. The figures of the pedigree serve as reference for the more detailed description of the individual cases.

The lack of permanent upper canines is known in the family to be hereditary. The milk canines, readily distinguishable from the permanent ones by the smaller size, more bulbous shape of crown and by partially or totally absorbed roots (see X-ray photograph, Figure 3*B*), often perists during the whole lifetime. In other cases they may be lost on one side or on both sides. The existence of this anomaly in I-1 was known for certain to his son, II-2, who died a few years ago. The anomaly in II-2 is known by the report of his daughter, III-6, who is herself a dental surgeon and a carrier of the anomaly. With the exception of these two cases (I-1 and II-2) all other members of the family have been actually investigated, and in all pathological or suspicious cases, plaster casts and X-ray photographs have been taken. The investigation of the wisdom teeth was confined to the middle branch of the family, into which this anomaly was introduced by an unrelated woman (II-3).

We give first a description of the affected cases with respect to the anomaly

*My attention was drawn to the case by Dr. med. dent. Elsbeth Grüneberg. I have also to thank Dr. C. S. Rumsey (Cambridge) and Dr. G. Stock (Berlin), who kindly took some X-ray photographs for me, and Mr. C. H. Osterstock (John Innes Horticultural Institution, Merton) for the illustrations.



of the canines (black circles in pedigree —Figure 4).

II-4. (Figures 3*A* and 3*B*) Persisting deciduous upper canines bilaterally. No permanent upper canines.

III-5. (Figure 3*C*) At the time the patient was investigated and plaster casts and X-ray photographs taken, there was a persistent right upper milk canine, while the left one was already lost. In the meantime, the persistent deciduous tooth has been lost too. Lack of permanent upper canines.

III-6. (Figure 2*A-D*) The persistent upper milk canines have been extracted since it was hoped to get a better cosmetic result by application of an orthodontic device. The attempt, however, to close the gaps by means of a fixed appliance proved unsuccessful, as shown in Figure 2*A*.

III-7. (Figure 2*F-H*) The persistent deciduous upper canines have been extracted for the same reason as in III-6. Here the spaces were wide enough to allow for a bridge with porcelain pin teeth to cover the gaps.

The cases so far mentioned are uniform, and vary only with regard to the persistence of the milk canines. There is, however, one patient exhibiting a different situation.

III-4. (Figure 3*D*) Here the deciduous upper canines persist as in other members of the family, but the permanent ones are not lacking, but erupted behind the upper incisors. At first sight,

TOO FEW TEETH AND TOO MANY

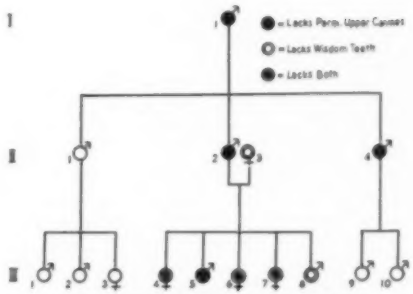
Figure 3

A-B. Plaster cast and X-ray photographs of upper jaw of II-4. The arrows show the persisting deciduous canine teeth on both sides. In the X-ray photograph (*B*) the dark shadow on the right is a bridge. *C* is a cast of the upper jaw of III-5, a nephew of II-4 shown above. In the upper jaw of this individual the milk canine tooth at the right is persistent, as shown by the arrow. That at the left is missing. *D* shows a cast of the upper jaw of III-5's sister, III-4. In her jaw the deciduous canine teeth have persisted, and the permanent canines have erupted behind the incisors.

this seems to be a fundamentally different situation, but it is assumed that the occurence of this case in the family is not an accidental one. It seems even to offer a possible explanation of the mechanism by which the lack of the permanent canines is caused. It is in fact difficult to imagine why the germ for a permanent tooth should be lacking while a perfectly normal deciduous tooth is present. One may assume, however, that originally a germ for the permanent tooth was formed. If such a germ for the permanent tooth is dislocated at an early stage, e.g. by abnormal growth processes, it might fail to develop into a tooth. If, however, the dislocation was of a kind which permitted the tooth to develop, it might erupt at an atypical place. This is what we believe to be the explanation of this case. The hypothesis of dislocation of the germ of the permanent teeth is not unlikely for the upper canines since those teeth are immediately adjoining the premaxillary suture. Here at the juncture of two bones the likelihood of dislocations seems greater than anywhere else in the set. It may be mentioned that to some extent this may be true for cases in which the lateral upper incisors are missing.

The pedigree leaves no doubt that the lack of the permanent upper canines is inherited as a simple dominant. In the family described it means no more than a cosmetic disturbance. It should be emphasized, however, that the biological importance of such an anomaly depends largely on the living habits of the species in which it is found. Should the same anomaly be found in a lion, it would mean a very serious handicap for the beast, and it would probably be classified as a sub-lethal factor.

The abnormality of the wisdom teeth (white rings in the pedigree) introduced into the family by II-3 has also been verified in II-3 and her five children by X-ray photographs. The discrimination against retention of teeth, which also occurs in some cases, is therefore certain for each individual tooth. No teeth have been extracted.



A COMBINATION OF TOOTH DEFECTS

Figure 4

A man (II-2) having defective upper canines inherited from his father, married a woman who had no wisdom teeth. In the five children various combinations of these defects appeared.

The following individuals in this family show this anomaly:

II-3. Right lower and left upper wisdom tooth missing. Left lower wisdom tooth tilted and retained, right upper wisdom tooth in normal position but not erupted. In addition there is a persistent left lower second milk molar. There is no check in the case of this tooth as to whether there is a permanent second premolar impacted in the mandible. By comparison with the cases III-7 and III-8, however, it seems unlikely.

III-4. All four wisdom teeth missing.

III-5. All four wisdom teeth present, but retained, the lower ones lying horizontally as the one in II-3, the upper ones lying obliquely with their crowns pressing against the roots of the second upper molars.

III-6. (Figure 2*C-D*) All four wisdom teeth missing.

III-7. (Figure 2*G-H*) Left lower wisdom tooth present and erupted. All other wisdom teeth missing. In addition, there is a persistent right upper second deciduous molar, while no germ of the permanent second premolar is visible.

III-8. (Figures 2*I-J* and 2*E*) Left upper and right lower wisdom teeth present, not yet erupted (the patient is 17 years of age). The two other wisdom teeth lacking. This boy is a mirror im-

age of his mother with regard to his wisdom teeth. In addition, there is a persistent right lower second milk molar, while the germ of the corresponding permanent premolar is missing.

There is thus a lack of two to four wisdom teeth in a mother and four of her five children strongly suggesting a dominant factor. The mother and two of her affected children show in addition a persistent second milk molar with lack of the corresponding permanent premolar. This seems not to be a mere coincidence, but suggests that the dominant gene which reduces the wisdom teeth tends to affect other teeth too, though obviously not so regularly. This fact makes the interpretation of the case more difficult. If only the wisdom teeth were affected, one might suggest that it was a reduction at the ends of the dental arches. The occurrence of anomalies in the premolar region shows the matter to be more complicated.

In view of the troubles so often encountered at the eruption of wisdom teeth, the gene causing their reduction may be regarded as favourable, having possibly a slight positive selective value.

Summary

1. Lack of permanent upper canines is caused in the family described by a simple dominant factor. The occurrence of a member in the family who has the permanent upper canines erupted behind the incisors leads to the assumption that probably the germ for the permanent canines is originally formed; owing to the vicinity of the premaxillary suture it presumably gets dislocated and usually does not develop into a tooth.

2. Lack of two or more wisdom teeth is found in a mother and four of her five children, suggesting a dominant factor for that anomaly. The mother and two of her affected children show in addition one persisting second milk molar indicating that the reduction of teeth is not confined to the ends of the dental arches.

AUTHOR'S NOTE:—Since this paper was sent to the press, Mrs. Lilian Lindsay (Hon. Librarian of the British Dental Association) kindly drew my attention to two papers referring to similar conditions. W. H. Dolamore (Absent canines. *Brit. Dental Journal* 1925: 5-8) mentions a case which is strikingly similar to that described in this paper. The patient, a major in the Indian Medical Service, had a persistent right upper deciduous canine and a gap in the left side. No trace of permanent upper canines was found in X-ray photographs. The patient who was aware of his anomaly was sure that his father also had no permanent upper canines. Although these data are somewhat meagre from the genetical point of view, there is little doubt that Dolamore's case is of essentially the same type as ours. The other case, described by T. W. Widdowson (A case of retained maxillary deciduous canines with a complete absence of permanent successors. *Brit. Dent. J.* XLIV:766-69, 1923) probably belongs to a different category since different groups of teeth are affected in the members of the family. The proband is the only one with lack of permanent canines and at the same time lacks all the four second premolars and one first premolar, the precursors being retained. Other members of the family (one aunt and two of her children) have lack of permanent incisors, and hair-defects were found in the proband "and many of her relations."

Recently, G. Schweitzer (Zur Frage der erblichen Bedingtheit des isolierten und symnetrischen Fehlens von Eckzähnen im bleibenden Gehiss. *Deutsche Zahn-, Mund- und Kieferheilkunde,* 1:236-52, 1934) described two cases, one of which showed a lack of all four permanent canines with three persisting milk canines, while the other is analogous to that described in this paper. Since in the respective families no similar case was found and the parents of the probands were not related to each other, no definite proof of an hereditary basis could be furnished.

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HAPLOIDS IN POLYEMBRYONIC SEEDS OF SEA ISLAND COTTON

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THE sporadic occurrence of seeds with two embryos has been frequently noted during the past few years in several types of New World cotton and their hybrids. During some germination experiments carried out in June, 1934, it was necessary to remove the testas of several thousand seeds of the Sea Island strain V. 135. It was noticed that twenty seeds contained two embryos, one of which was usually much smaller than the other. By careful culture sixteen pairs of plants were raised to maturity; of these, fourteen pairs consisted of *one haploid and one diploid,* and two pairs each of identical diploids. Some two thousand known mono-embryonic seeds were also planted out in the field, and among these occurred one haploid.

Haploid Sea Island cotton was first described[1] by the writer in 1920. Had it been cytologically examined at that time it would have been the earliest known haploid. but it was not till much later, that Skovsted (cited by Harland[2]) pronounced on its cytological nature. Any commercial field of Sea Island cotton usually contains haploids—known to the natives of Trinidad as "Man Cotton"—in the proportion of one in three or four thousand plants. The reason for the unusual frequency now becomes clear in the light of the observations described above.

Two cases of haploidy in Upland cottons (*G. hirsutum* L.), have also been recorded, both in the variety Acala Okra. One occurred in field culture and the other as one member of a pair of twins. Cases of twins have been noted from time to time in strains of mixed *hirsutum—barbadense* ancestry, and one at least consisted of one haploid and one diploid. On the other hand, neither twin embryos nor haploids have been found in Egyptian cotton (*G. barbadense* L. var. Enans Brown) although carefully sought for by my colleague, Mr. R. A. Silow. Other varieties of Egyptian have not been thoroughly examined.

Fertility of Haploids

According to the particular strain of Sea Island in which they originate, the haploids are somewhat fertile as female parents. No viable pollen seems to be produced. One haploid set practically every boll when pollinated by pollen from normal Sea Island, and even from the 13-Chromosome species *G. arboreum, G. harknessii, G. armourianum, G. anomalum, G. trilobum,* and *G. aridum.*

The bolls usually contained only one seed, though one pollination with *G. armourianum* gave two seeds, both of which germinated. Other Sea Island haploids were less fertile and a few were sterile, or practically so. The two Upland haploids were also completely sterile. It may be provisionally concluded not only that a genetic basis exists controlling the frequency of occurrence of haploids in different strains, but that the degree of fertility of the haploids is also a function of genetic constitution.

Practical Importance of Haploids in Breeding

If it were possible, by the decapitation method used by the tomato workers, to produce diploid shoots on the cotton haploids, we should have, *ab initio,* a pure line, the practical importance of which, to the breeder, would be considerable. Such is the heterozygosity in commercial cottons that even after 17 generations of self-fertil-

ization in Sea Island cotton, selection for certain quantitative characters had a pronounced effect. It is at present admitted that no pure lines of cotton have ever been produced, although some Sea Island strains maintained by self-fertilization since 1917 constitute fair approximations to homozygosity. Given standard haploids of desirable genetic constitution, it is possible, by repeated matings of the same haploid × brother diploid to arrive at a progressively closer approximation to the genetic constitution of the diploid corresponding to the standard haploid. Repurification of a commercial strain could be effected at any time,—the haploid being maintained by vegetative multiplication.

Lack of homozygous material has previously rendered it impossible to undertake with profit studies of inheritance of quantitative characters in cotton. By using a standard haploid as a base it should be possible to learn something of the mode of inheritance of such characters as lint length or hair weight. It seems likely that genetical purity will not be attained more quickly by repeated back-crossing to the haploid than by selfing a heterozygote of unknown complexity. Nevertheless the stable genotype of the haploid provides a base towards which the product of repeated back-crosses continually converges. The self-fertilization of heterozygotes may result in the selection of types which owe their superiority to the heterozygous phase of one or more genes, and in any case is not directed towards any particular known genotype.

The production of haploids in large numbers in *hirsutum* × *barbadense* crosses may help in synthesizing types embodying the desirable features of both species. As pointed out by the writer[3] *hirsutum* and *barbadense* are profoundly different in their genetical architecture, and the F_2 of crosses between them exhibits a series of types characterized by varying degrees of sterility and environmental maladjustment. Since the tendency to produce haploids is genetic it would be possible to obtain haploids possessing various combinations of *hirsutum* and *barbadense* characters. Several important characters could be recorded in the haploids, with the assurance that the corresponding diploid would also possess them to a similar degree. Resistance to Blackarm (*B. malvacearum*), lint length, colour and fineness, and seed fuzz are among the characters obviously desirable to study. Freedom from undesirable recessives such as chlorophyll deficiency would be apparent on inspection, and the existence of great vigor in the haploid could be fully exploited, since it would not, as in diploids, be complicated by vigour due to heterosis.

Haploids Crossed with 13 Chromosome Species

As mentioned above, it was found possible to make crosses between a Sea Island haploid ($n = 26$ chromosomes) and various 13-chromosome species, and it is likely that interspecific crosses of this type are easier to produce than when the diploid type of Sea Island is used as the seed parent. A cross was made between haploid Sea Island and *G. anomalum*, a wild species from Africa. This hybrid has not previously been recorded.

The main object in making crosses of haploid by 13-chromosome species was to see whether the haploid would, in addition to the usual 26 chromosome eggs, produce also 13-chromosome eggs carrying one or another of the two subgenoms which are believed (Skovsted[7]) to constitute the amphidiploid *G. barbadense*. Combinations of such 13-chromosome eggs with the corresponding 13-chromosome gametes from wild species have so far not been found, though it seems worth while to carry out the experiments on a much larger scale. So far the crosses of 13 chromosome species with both haploid and diploid Sea Island seem to be identical.

Discussion

Polyembryonic haploidy, that is, the simultaneous presence of a haploid and a diploid in a single seed, was noted by Ramieh and his co-workers[5] in rice,

Oryza sativa. They have subsequently stated,[6] that while polyembryonic haploidy was common in one variety of rice it was absent or rare in others, and only in one case involved haploidy as well. It is therefore uncertain to what extent polyembryonic haploidy exists in other plants, though the prevalence of it in cotton indicates the probability of its occurrence in other genera. The appearance of haploids in relatively large numbers in fields of rape, *Brassica napella*, was noted by Morinaga and Fukushima[4] though not apparently in connection with polyembryony. A final suggestion may be made, in spite of the fact that the cytological features accompanying the development of polyembryonic haploidy in cotton have not yet been worked out. It seems that as allopolyploidy initially involved the meeting of two unlike genoms, some degree of polyembryony might arise as a primitive character brought into expression by genic disharmony. If as seems probable, polyembryony in cotton involves the production of more than one embryo sac, an opportunity is thereby provided for the development of an embryo from an unfertilized egg alongside its fertilized neighbor. As we have seen, the occurrence of haploids in allopolyploid cottons is usually, though not always, associated with polyembryony, and it is perhaps significant that haploidy has not yet been recorded in the 13 chromosome Asiatic species.

Summary

1. The occurrence of polyembryonic haploidy is described in two species of New World Cottons, *G. barbadense*. L. and *G. hirsutum*. L.

2. Variations in the frequency and degree of fertility of this type of haploidy are probably due to genetical factors.

3. The practical importance of haploids in cotton breeding work is discussed.

4. Reference is made to the possibility of effecting combinations between either of the 13-chromosome sub-genoms of New World cotton and the corresponding 13-chromosome genoms of certain wild species.

5. The inter connection between allopolyploidy and polyembryonic haploidy receives brief mention. It is thought that polyembryony in allopolyploids may be a primitive character brought into expression by initial genic disharmony through the meeting of two unlike genoms.

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THE TEST OF THE MARKET PLACE

A Review

THIS first volume of the Harvard Sociological Studies is an important book* because it is a realistic survey of practically the whole field of social science by one of America's leading scientists. Dr. Carver's conclusions have more than forty years of research and scientific thought to support them. Nevertheless the author tells us in his preface that the book is a compromise between his abilty and his ambition to publish a monumental work on the general subject of social evolution.

The author sets out to answer five important questions asked in his preliminary survey. Three of these questions are of more or less academic interest, while the second and fifth are of great practical importance and are of considerable interest to society at the present time. These questions are: (1) Why do men have so much trouble getting along with one another when it is so obviously to their advantage to live and work together? and (2) what can we do to solve this problem?

In considering the first of these two questions the author describes two general theories of approach. First, the theory that some tainted or evil influence outside of man causes friction among men. While modern society has pretty much gotten away from the idea that a devil or evil spirit causes trouble in human societies, some modern thinkers hold to the idea that our social order plays much the same role as the Devil in the old theology. Carver believes that an answer more in harmony with the evolutionary philosophy of the day is that we have trouble living together because we have not as yet evolved into a thoroughly socialized species.

In answering one of the more theoretical questions, "Has man a social nature?" the author says that it is safe to say that human nature is somewhat socialized, but not sufficiently to prevent a conflict of interests wherever scarcity of desirable things shows itself. Thus the chief reason why men do not live together peacefully is because of a conflict of interests over the good things of life. And the chief reason why there is a conflict of interests over desirable things is explained by Darwin's work on evolution: "Darwin learned from Malthus to correlate two facts, 1. that life tends to reproduce itself in large numbers; 2. That only a limted number of any form of life can live in a limited area." Thus the conflict between men boils down to a conflict between man's hunger for sex and his desire for other things of life.

He considers that one of the most difficult phases of the problem of poverty is that it grows out of the sheer fecundity of mankind,—in other words "it is the population problem." In many parts of the world, we are told, the pressure of population is so great as to almost cause a student to despair of any improvement in the general conditions of the people.

The law of diminishing returns Carver sees as one of the greatest facts of history. Emigration of people or importation of goods produces no negation of this law. But the situation is by no means hopeless. The law of diminishing returns "closes the door of hope" to the social reformer only in the sense that gravitation closes it to the aviator; and hopelessness, says the author, is no more inherent in a world of diminishing returns than it is in a world of gravitation. (To deny the existence of the one set of forces would seem to be only less stupid, and fraught with as much danger, as to deny the other.)

The Social Team

The author concedes that none of the Western countries is suffering from gen-

*CARVER, THOMAS NIXON. *The Essential Factors of Social Evolution.* Pp. xi—564. $5.00. Cambridge, Massachusetts: Harvard University Press, 1935.

eral overpopulation, but he says that every country without exception, is suffering from congestion of population in one form or another. Certain occupations are over-manned, and there is need for different kinds of labor as well as for a balance between population and land. One important cause of this occupational congestion is the present differential birth rate among occupational groups. This may be cured (1) by reducing the numbers of unskilled, and (2) increasing the number of managers, inventors, etc. This refined theory of population points the way to the only constructive or permanent remedy to lower wages, unemployment, and mass poverty.

The first and greatest of all leading principles of sociology is that social life is essentially teamwork which consists in doing with all one's might whatever is necessary for the success of the team. It ought to be apparent to any unprejudiced and thinking person that the success of a great society, as of an athletic team, depends somewhat on the quality of its personnel. An athletic team which relies wholly on its system of training, and pays no attention whatever to the native capacity of those selected for membership would stand a poor chance against a team which both chose and trained its members wisely.

There are only two ways by which the members of the great team called society, tribe, state, or nation, can be chosen. One is infanticide, destroying as Plato suggested in his ideal republic, those adjudged unsuitable for citizenship. The other is by preventing the birth of those likely to prove unfit because of the undesirable quality of their potential parents, and encouraging the birth of those likely to prove fit because of the desirable quality of their potential parents.

Who Are the Fit?

The author then considers the important question: What is an effective method of eugenic selection? How can we tell who are fit and who are unfit? Up to the present, he knows of no better test than that of the market. The fit are those who do well something that the group wants done and is willing to pay for or, briefly, those who produce economic goods or services that are of marketable value. The author admits that this is not a perfect test and that it will need to be modified in some particulars, but he believes it is the best working plan we have at present.

The author's ideas on eugenics are consistent with his ideas on economics and politics. He is a champion of democratic capitalistic market economy. He does not pretend that the capitalistic market economy is perfect and he readily admits that it can stand considerable improvement. The two principal grounds for indicting the present economic system of the Western world are its instability and its inequitability. The indictment is well founded. A market is an unstable thing; prices fluctuate, and everything in our system seems to be in a state of flux and flow. The only way to avoid this difficulty appears to be to appeal to some form of authoritative standardization of economic variables. This type of control Carver colorfully designates the "Military system." Under a military form of organization the individual may think he is more secure, but he does not have the same opportunity for advancement, and he will have to accept everything that goes with a military scheme of things, with its attendant arbitrary regimentation of the individual.

Every advancement in an economic system from the natural, barter, money, and, now, credit economy has been marked by greater complexity, and therefore greater inequality and instability for those less capable of advancement. Whether the Western world will be able to maintain its system of voluntary market economy, or must suffer a reversion to the military system (which would seem to the reviewer to include either fascism, communism, or paternalism), will depend on the relative percentage of people who wish to preserve their liberty and opportunity for advancement as compared with those who are willing to surrender their freedom of ac-

tion to risk a life that they hope will offer a slightly greater degree of security.

Carver is convinced that price fixing either by great business monopolies or by the government is not the answer to the inequality and instability of the market economy. The desires of individuals for goods make the market economy, and while it may be that individuals may not always desire what is best for them, they are not likely to show any greater intelligence when they come to vote for government officials to control their desires and businesses. Neither is the problem solved by dictatorship, "for dictators are not likely to be beneficent and mild." One of the best means of stabilizing prices and doing away with inequality, and to discourage speculation in our present system of market economy, says the author, is a more intelligent control of credit. This could be accomplished without arbitrarily expanding or contracting production and employment. Probably the greatest opposition to the author's conclusions concerning eugenics and economics will come from ultra-sentimentalists and from those who have not been able to produce very much that is of marketable value.

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THERE MUST BE CHECKS

MAN has always had to be kicked upstairs, he never went voluntarily. The higher life is always a hard life. The names splashed over the pages of history are not of those whose lives were happy or easy; happy lives never made history. The names which are etched on indelible bronze and sung by generations following are of the men of sorrows who have been acquainted with grief.* * *

The reward of the industrious is not ease—it couldn't be. The reward of the industrious is more work, more responsibility, more dependents. Having been faithful in a few things they became rulers over many. Those are the plums nature scatters. Whether with an individual or a race, the price of ease is destruction—social security is the toboggan slide. * * *

When nature added intelligence to instinct she assumed a precarious hazard, for intelligence is always seeking an easier way—and finding it! Intelligence has never fully agreed with the natural doctrine of survival of the fittest—she has denied it in argument and has tried to provide substitutes for it in practice. Without some checks the race could not survive, but there are easier checks than natural selection. Easier? Yes, but are they as fool proof? Let me mention three ways in which modern civilization is combating natural selection.

Probably there is no one of our modern achievements in which we are so inclined to glory as in the really marvelous accomplishments of modern philanthropy and modern medicine. But philanthropy which has established hospitals and institutions to prolong the lives of the unfit may be at times of doubtful value. The result has been a protected race rather than a resistant race, and some day the protection may find itself inadequate and the race will be decimated if not doomed. Of course, the injury is not in prolonging the lives of the unfit in itself, for the end of the generation would be the end of the menace, but prolonging the lives of the unfit to become the breeding stock of the nation is suicidal. Nature's method is immunity, that is, doing away with individuals who are susceptible to certain diseases, and breeding from the immune. Thus the Negroes are immune to malaria and the Arabs to typhoid fever. Of course, such a scheme requires a telescopic vision rather than a microscopic one. On the other hand, for example, there is every reason to think that, now that we are saving the lives of so many persons who are susceptible to tuberculosis and permitting them to breed, soon tuberculosis will become more prevalent. * * *

The tragedy of the war was not that millions of men lost their lives, as horrible as that is to contemplate, but that the finest breeding stock of all the nations involved was destroyed—and can never be replaced. I suppose the biologists might tell us that an equal number of persons from each nation could have been selected to be eliminated, the withdrawal of whom would have greatly improved the race, but those were not the ones chosen. As in days of old, the sacrifice must be without spot or blemish.

Not less dysgenic than these two other factors is a new one, with the voice of Jacob but the hand of Esau. It is called social security. The race has come to its present high position by means of the most relentless competition, strife, and struggle. Bodies and minds bear on them the stigma of battle. Individuals, communities, and races have risen or fallen as they have been forced to struggle; social security for any of them meant defeat and decline. Easy lives never meant vigorous personalities, soft living never meant strong bodies or keen minds. It is only as we have been

(Continued on page 240)

SATIN, A NEW HAIR MUTATION OF THE RABBIT

With a Chromosome Map of the Rabbit*

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HAIR is a structure peculiar to mammals. Found even in such primitive types as the egg-laying duckbill and in such extremely modified forms as the whale, it is best developed in the commoner terrestrial types of mammals. A genetic basis for hair production undoubtedly is found in all mammals, but is subject to great modification through gene mutation. Best known, because most conspicuous, are variations in the color or structure of the hair. These have been studied most thoroughly in rodents bred in captivity,—particularly rabbits, guinea pigs, rats, and mice. In the domestic rabbit, which has 22 pairs of chromosomes, at least 10 gene mutations affecting the hair have been described which are thought, on the basis of good experimental evidence, to be mutually independent. If they are, these genes must be located in as many different chromosomes. It seems possible, accordingly, that every chromosome of the rabbit contains genes which affect the character of the hair. Whether a rabbit could exist without these hair genes and whether, if it could, it would still be a mammal and produce hair is a matter about which we can only speculate. Such questions are involved in the general question—is the individual mammal merely the sum total of its genes, or is it an individual conditioned or modified by the genes borne in its chromosomes, as it clearly is also by its external environment?

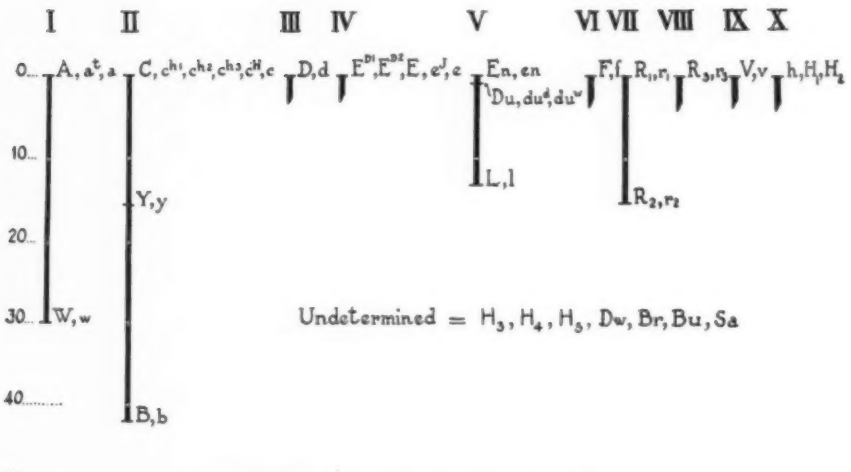
Without attempting to answer this general question (at present an obvious impossibility), we may pause to consider what sorts of modification genes are known to exercise on the structure of the hair of the domestic rabbit, and to describe a newly discovered hair mutation, "satin."

Known Genes

The hairy coat of wild rabbits is a protectively colored gray above with lighter colored (whitish) under surfaces. This pattern of body coloration is combined with a pattern of the individual hairs known technically as "agouti," the typical agouti hair having an intense black tip, a subapical band of yellow, and below that black again which grows less intense and becomes bluish toward the more slender base of the hair. A single *agouti* gene (*A*) controls the regional distribution of pigment both on the body as a whole and on the individual hairs. It has, among domestic rabbits, undergone two different retrogressive mutations which are recessive alleles of typical agouti. These are (1) *black-and-tan* (a^t), in which the regional body pattern (whitish under surfaces) persists but the pattern of the individual hairs is largely suppressed; and (2) uniform *black* (*a*), in which both body pattern and pattern of individual hairs are lost. The order of dominance among these three alleles is agouti, black-and-tan, and black. The chromosome which contains the agouti gene contains only one other known gene (wide band, *w*), which acts as a modifier of the width of the agouti banding (Sawin). The crossover percentage between these two genes is about 30 (see Chromosome I in map — Figure 5).

A second chromosome (II) of the rabbit contains a gene which we call *black* (*B*), which in recent years has mutated to brown (*b*), a recessive allele of black. In this mutation a

*Prepared by Dr. C. E. Keeler.



CHROMOSOME MAP OF THE RABBIT

Figure 5

Fifteen genes have been located in ten of the twenty-two chromosomes of the rabbit. The linkage relations of five or six other known genes have not been sufficiently studied to determine whether they mark other chromosomes, or are resident on some of the ten "known" chromosomes. Linkage studies show that two of the chromosomes (II and V) carry three known gene loci each, and that two of the chromosomes carry two known loci (I and VII). In the other six "known" chromosomes, linkage relations have demonstrated independent inheritance, indicating that these marker genes are located on separate chromosomes. Further research may demonstrate loose linkage with other known genes, which would require the re-drawing of this provisional map. Prepared by C. E. Keeler.

chocolate brown pigment replaces black not only in the hair but also in the skin and eye of the rabbit. This chromosome contains two other important genes of the rabbit. One is the so-called color gene (*C*), necessary for the development of pigment anywhere in the body (hair, skin, eye). It has undergone a graded set of retrogressive mutations including (1) chinchilla (dark, medium, and pale, ch_1 ch_2, ch_3, —three different alleles, in which yellow pigment is largely suppressed but black persists); (2) Himalayan albino (c^H), which has pink eyes and a coat unpigmented except at the extremities; and (3) the true or complete albino (*c*), unpigmented everywhere. This same *second* chromosome contains a third gene, located midway between the other two, which controls the color of body fat. Wild rabbits and ordinary domesticated ones have white fat, but a recessive mutation which affects the metabolism of ingested green food makes the fat yellow in color (*y*).

A third chromosome (III) of the rabbit contains a gene which controls the intensity of the pigment in hair and skin. In wild rabbits and ordinary domesticated ones all pigments are intense, but a recessive mutation, dilute (*d*), changes intense agouti to dilute agouti, black to blue, and yellow to dilute yellow. No other mutant gene is known to occur in this chomosome.

A fourth chromosome (IV) contains a gene which controls the relative amounts of black and of yellow pigment in the coat. In wild and ordinary domestic rabbits black is produced *extensively* (*E*) throughout the coat, but in the recessive mutation (*e*) black is largely restricted to the eyes and extremities, the greater part of the coat being yellow pigmented. Dominant

mutations of this gene, known in two alleles (E^{D1} and E^{D2}) produce a supernormal extension of black or brown pigment, so that the agouti banding is largely obscured in the variety known as steel or completely obscured in the variety described by Punnett as dominant black. A mosaic distribution of black and yellow in the coat results from the allele known as Japanese (e^J), which is recessive to E but dominant to e. Five alleles in all have been described for this gene, two dominant to the normal and two recessive to it. No other gene has yet been identified as occurring in this fourth chromosome.

A fifth chromosome contains three known genes, all of which affect the character of the coat. Two of the genes closely linked with each other produce, in their mutant state, patterns of white spotting known as English and Dutch, respectively. Of the latter three alleles are known. A third gene more loosely linked with these two produces, in its mutant state (1), the so-called angora modification of the coat, in which the hairs are of much increased length and fineness, so that they can be utilized industrially as wool.

A sixth chromosome contains the recessive mutant gene, *"furless"* (*f*). In this mutation only the coarser and longer hairs (the so-called guard hairs) attain full development. The finer and softer "wool" hairs, which are much more numerous than guard hairs in the normal coat, are entirely wanting in the furless rabbit, the skin being dry and scaly where wool hairs would normally occur.

A seventh chromosome contains two genes which, in their mutant form, shorten the hair, frequently obliterate the distinction between guard and wool hairs (all alike being soft and wooly), and cause a twisting or curling as well as a shortening of the vibrissae. These mutations have similar effects on the coat, but neither one is effective unless homozygous. Hence, though each is true-breeding, a cross between the two produces individuals having a normal coat. These mutations are known as "rex" No. 1 and "rex" No. 2, respectively. The crossover percentage between them is about 17.

An eighth chromosome, otherwise unmarked by mutant genes, contains a third recessive "rex" gene (r_3), which has somatic effects indistinguishable from those of rex_1 and rex_2, yet is inherited quite independently, though also as a mendelian recessive. Its action is also physiologically different and complementary, since crosses of rex_3 with rex_1 or rex_2 alike result in the production of normal (not rex) offspring.

A ninth chromosome contains a recessive mutant gene which produces an all-white coat, though the eyes are colored. This mutation is known as *Vienna white*, from its place of origin. It is not a true albino mutation, for in crosses with albinos, colored young are produced.

A tenth chromosome contains a gene which, though not known directly to affect the coat, controls the production of certain agglutinogens in the red blood cells which form the basis of the so-called blood groups. This gene has three known alleles, h, H_1 and H_2. Three other blood group genes, recently discovered by Fischer[1], have not yet been studied in their linkage relations and so can not at present be assigned to any chromosomes or linkage systems.

Our knowledge is also incomplete as regards the linkage relations of (1) a gene for dwarf body (*Dw*), lethal when homozygous but merely reducing body size when heterozygous; (2) a gene for short or imperfect digits, known as brachydactyl (*Br*); and (3) a gene for buphthalmus (*Bu*), an eye malady resembling glaucoma in humans. It seems probable that several of these will constitute chromosome markers when their linkage relations have been fully canvassed.

The "Satin" Gene

It is the primary purpose of this paper to describe a new hair mutation of the rabbit known to breeders as "satin" (*sa*). It was discovered about the year 1930 by Mr. Walter A. Huey,

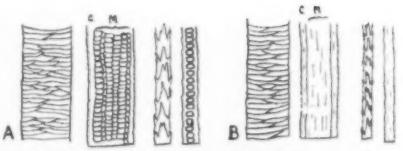
of Pendleton, Indiana, to whose kindness, and that of Mr. W. L. Cotta, we are indebted for the opportunity to study it, and also for breeding stock. When this mutation made its appearance, Mr. Huey was attempting, by intensive inbreeding and selection, to improve the color of the chocolate brown breed of rabbits known as Havana. In the course of his experiments he obtained an occasional rather puny individual which, however, had an unusually dark and glossy coat. At first these were discarded as lacking in stamina, but when later a few were reared, they proved to have a very attractive coat and became the foundation of a new variety of Havana rabbit known as the satin Havana.

We have found the satin mutation to behave as a simple recessive character. Satin Havana, mated with ordinary Havana, produces the ordinary type in F_1, with segregation in F_2 into 3 ordinary to 1 satin. In backcrosses to satin a 1:1 ratio is obtained.

Tests have been made to discover whether satin is linked with certain other rabbit mutations but so far with only negative results. Recombinations have been obtained in F_2 between satin and the following recessive characters with such frequencies as to indicate free assortment: albinism, angora, extension, furless, rex_1, and rex_3. Backcross matings between F_1 and a double recessive show that no linkage exists with the dominant genes agouti, English, and the blood group gene H_1. The test with English supports the F_2 test for angora, since English and angora are borne in the same chromosome. Backcross tests with brown (in association with which satin entered all crosses) show that satin and brown assort independently. This supports the F_2 test with albinism, since brown and albinism are borne in the same chromosome.

Tests have not been made for linkage between satin and dilution, satin and Vienna white, satin and dwarf, or satin and brachydactyl.

The coat of the satin rabbit appears smooth and glossy from its first emergence, and this condition persists



STRUCTURE OF NORMAL AND "SATIN" HAIR

Figure 6

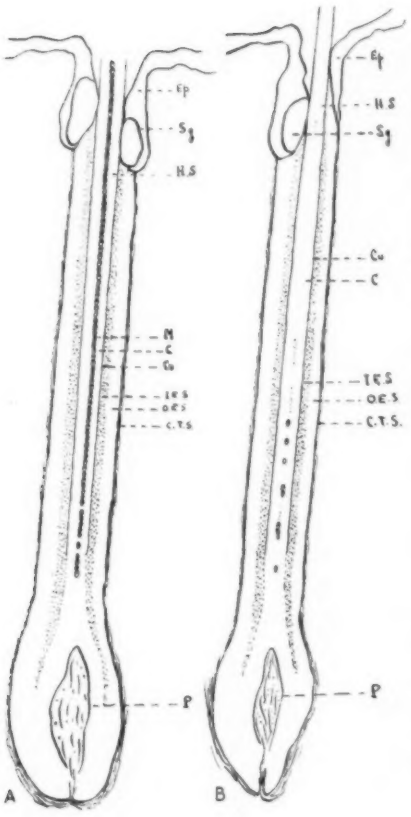
A—Surface view (at extreme left) and optical section (next right) of one of the large guard hairs, at its maximum diameter, in a normal rabbit, age about two months. The surface view shows fabrication of the cuticulum; the optical section shows the vacuolated and air-filled medulla occupying most of the interior of the section, peripheral to which are the cortex and cuticulum. The smaller drawings at the right show similar views, at the same magnification, of a portion of one of the small wool hairs of a normal rabbit. The medulla here contains a single row of vacuolated air-filled cells.

B—Four views of satin rabbit hairs (taken from a litter mate of the animal supplying the hairs shown at *A* and drawn to the same magnification. The medulla is here devoid of air-filled cells and is really continuous with the cortex, though a boundary line between them to show their relative thickness has been introduced in the optical section of a guard hair (second drawing from left). Note the lesser diameter of satin hairs as compared with normal.

throughout life. To the touch, also, the hair is unmistakably smoother than ordinary hair. The relation is similar to that of a mercerized cotton fabric to ordinary cotton cloth. Examination of the hair under the microscope shows that the individual hairs are both more slender and have a thinner cuticulum than ordinary hair. The thinner and smoother cuticulum increases the visibility of the pigment contained in the hair shaft, just as a glaze brings out the coloration of pottery. The coat colors thus gain in brilliancy and beauty. In making preparations for microscopic study, hairs were taken from white spotted (Dutch) individuals, since in their white hairs pigment would not by its presence interfere with the observation of structural details.

Structure of the Hairs

The structural peculiarity of the satin hair seemed to us, on first inspection,



SECTIONS THROUGH HAIR FOLLICLES

Figure 7

A — Diagrammatic longitudinal section through the follicle of a normal hair, from a rabbit aged two days. The medulla (*M*) in the developing hair shaft consists of a single row of vacuolated cells. *H.s.*, hair shaft; *Ep.*, epidermis; *sg.*, sebaccuous gland; *M*, medulla; *Co.*, cortex; *C*, cuticulum; *i.e.s.*, inner epithelial sheath; *o.e.s.*, outer epithelial sheath; *c.t.s.*, connective tissue sheath; *P*, papilla.

B — Diagrammatic longitudinal section through the follicle of a satin hair from a litter mate rabbit aged two days. Only a trace of the degenerating medulla remains in the hair shaft, and the medulla is apparently wholly wanting in the fully formed hair as it emerges from the skin.

to be a complete absence of medulla—and such, from a purely descriptive anatomical standpoint, it is—but a study of sections of the hair follicles in newborn or very young rabbits, made by Mr. Law, showed that a distinct medulla is really present in the developing satin hair, though it later disappears almost or quite completely.

The normal rabbit hair, as it emerges from its follicle at the level of the skin, consists of a pencil of closely compacted and heavily keratinized cells, all of which are perfectly dead and dry. The compacted cells contain abundant pigment granules which give to the hair its characteristic color. In white hairs pigment granules are lacking, and white light is reflected from air spaces in the interior of the hair.

Structurally we may distinguish in a cross section, or a longitudinal section (Figure 7*A*) of a hair, three regions. At the center is the medulla covering from a half to three-fourths or more of the hair diameter. It consists of cells resembling the pith of a plant stem. They have rigid walls of horny material surrounding an air-filled interior, in the walls of which (in the case of colored hairs) pigment granules are imbedded. Outside the medulla comes the cortex, or "shell" of the hair, a dense stratified horny structure nearly transparent when pigment granules are wanting, as in white hairs. Its outermost layer of cells is usually distinguished as cuticulum. This is composed of scale-like flattened and dried cornified cells which overlap like the shingles on a roof, sloping toward the tip of the hair. This arrangement of the scales is visible to the naked eye in the so-called "quills" of the porcupine, which are hairs of exaggerated size. The overlapping scales of mammalian hairs form very characteristic patterns of fabrication which (together with the internal structure of the hairs) have been carefully studied and described by Hausman[2] and which serve to identify the species from which hairs are derived and so are useful in the detection of fraudulent practices among furriers.

It would seem that in the "satin" hair of the rabbit all cell walls, when keratinized, are thinner than those of normal rabbit hairs. This leads to modification of all three regions of the hair shaft. The cells of the medulla, instead of retaining their original cuboidal shape and becoming filled with air as they dry up, collapse and become compacted together into a stratified structure continuous with and similar to the cortex (compare Figure *6A and B*). The cortex and cuticulum are both thinner than in normal hairs, because the walls of the constituent cells are thinner. For the same reason the fabrication of the cuticulum is less conspicuous and its surface smoother, which in turn makes the hair colors more brilliant.

It is yet to be demonstrated whether the satin mutation possesses possibilites of economic utilization. Like the rex mutation, it adds to the resources of the rabbit fancier by greatly increasing the number of interesting and beautiful character combinations at his disposal. From the utility standpoint, it probably decreases the growth energy and survival value of an animal to possess a satin coat, yet by suitable crosses vigorous strains can be produced having a satin coat. The angora satin combination produces wool so extremely fine and soft that its yield on a quantity production basis would probably be small. Like the rex mutations, satin is at present a new plaything and a new tool of investigation for the fancier and the geneticist.

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1. Fischer, W., 1935. Ueber Blutgruppeneigenschaften beim Kaninchen. *Zts. f. Immunitätsforsch.* 86, H. ½.

2. Hausman, L., 1920. Microscopic identification of common fur hairs. *Sci Monthly* 10.

◆

THERE MUST BE CHECKS

(*Continued from page* 234)

forced that we have pushed forward. Now comes social security to guarantee us soft living from the cradle to the grave, to beg the unfit to become more unfit, and to beg the fit to give up the struggle and to vegetate. Every avenue is open to a life of indolence and supineness. * * *

In the nineteenth century — the biologists' century — one word reigned. That word was "evolution." To many, however, evolution was not a theory of man's development but an irresistible force pushing us upward, whether we wished to go or not. The twentieth century has given us a new word—and a sinister one; that word is "degeneration." It is a surprise to some that degeneration is just as much a fact and just as much a possibility as evolution. In fact, some biologists affirm that many present species have attained their present forms not by evolution but by degeneration. Let us not be deceived, when (because it is the easier) we choose a lower order instead of the higher, when both are permitted to us, we have started down-stairs.

If there is danger in removing nature's checks, is there no security except we restore them? Can we not conserve the fine things philanthropy and medicine have given us and continue to improve the race? We do not know; perhaps so! We are sure of one thing, however, there must be checks. The danger is in removing natural checks and substituting nothing else. We are experimenting with three which we hope will be successful, but if so they must be applied and applied faithfully. The first element in higher control is intelligence—none too plentiful a commodity. Usually when we try to apply it, it is sidetracked by maudlin sentimentality. * * *

The next element in higher control is morals. What are morals? They are a code embodying what we think is a reasonable way of living together. Our recent trouble was a moral trouble. We have been talking about money and credits and production and distribution, when underlying all these were morals. We had the world organized on a moral basis, but ran short of morals, like trying to run a business on a cash basis when we are short of cash. Morals are our second great need if we are to dislodge natural checks.

The third higher control is religion. After the war many were enamored of Donald Hankey's definition of religion as "Betting your life that there is a God." That is not big enough for the kind of control we need. Religion is betting your life that you are a god and acting accordingly. When we have this control, perhaps we can scrap natural checks, but "A civilization which removes natural checks before it fosters higher controls is committing suicide." — George Barton Cutten. Excerpts from Convocation Address delivered at Colgate University, September 25th, 1935.

POLYPLOIDY IN SEDUM TERNATUM

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THE 2*n* chromosome number for uncultivated plants of *Sedum ternatum* was reported by Baldwin[1] to be 32. Subsequent investigation of this species indicates those plants, and most of the others studied, to be tetraploid and reveals the existence in the wild of a diploid race. In the present paper, diploidy and tetraploidy within *S. ternatum* are cytologically compared.

S. ternatum "is primarily a woodland plant and grows not only on shaded rocks, but also on alluvial flats along streams" (Wherry[5]). It is differentially distributed throughout the area delimited by Massachusetts, New York, Indiana, Missouri, Tennessee, and Georgia. Through this area, which covers a north-south range of about ten degrees, the Appalachian Mountains extend. The natural distribution of the species has probably been little disturbed by cultivation. Determination of the relative frequency of its diploid and polyploid forms will be of phylogenetic significance. Furthermore, the species, because of its polyploidy, its almost undisturbed occurrence in nature, its variable climatic environment, and its readily accessible distribution area, apparently affords a favorable medium of attack upon the relationship possibly existent between polyploidy in closely cognate plants and temperature differences as conditioned by altitude or latitude. If such a relationship exists, its expression should be positively correlated with the extent to which the plants are evolutionally allied; so, in considering this problem, polyploidy within a single species would be more suitable than polyploidy within a group of closely related species.

S. ternatum will be investigated with regard to the problem outlined. The sending, therefore, to The Blandy Experimental Farm, Boyce, Virginia, of living specimens of this species collected from the wild, with designation of the source locality and its approximate elevation, will very much facilitate this study and will be sincerely appreciated.

Material and Methods

Seven lines of *S. ternatum*, obtained from different sources, have been investigated. All of the lines are now growing at The Blandy Experiment Farm. Two of them had been previously in cultivation.

Paraffin sections of anthers and of root tips fixed in Nawaschin's solution were made at a thickness of 7 - 13 μ and stained by the crystal violet-iodine method. Aceto-carmine smears were made of anther and root-tip materials succeeding their fixation in Carnoy's fluid. The formula for Carnoy's given by Chamberlain[2] was followed.

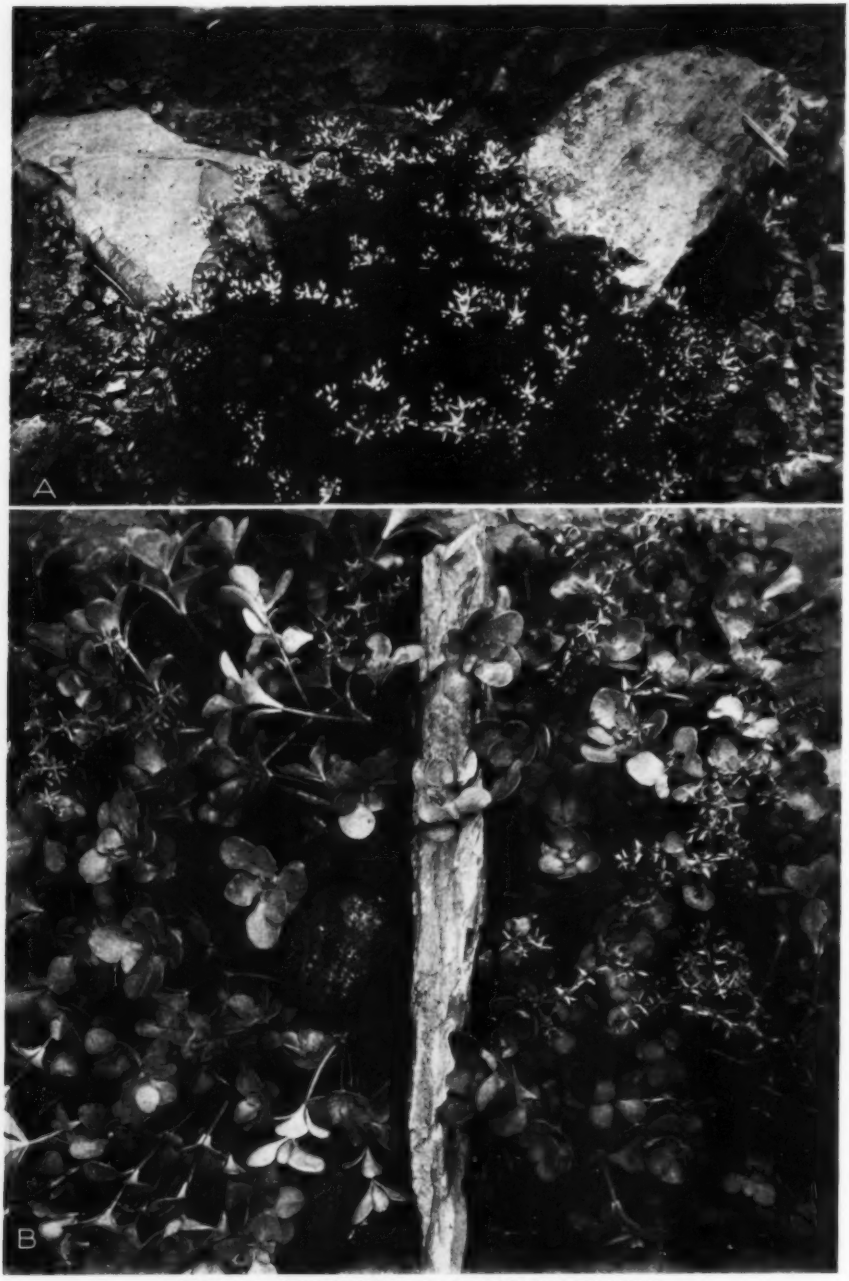
Drawings were made with the aid of a Zeiss camera lucida and at a magnification of $\times$ 4900; Figure 10, however, was drawn at a magnification of $\times$ 1750, Figure 11 at a magnification of $\times$ 2650, and Figure 12 at a magnification of $\times$ 440. A Zeiss microscope equipped with a $\times$ 30 compensating ocular and a $\times$ 90 oil immersion objective, n. a. 1.25, was used in conjunction with Wratten filters.

Observations

In Table I are given for each of the lines investigated the number of the line, its source, and its chromosome number.

Line 64C is diploid. It has sixteen chromosomes at mitotic metaphase (Figures 9*A* and 9*B*). In aceto-carmine

* The writer wishes to thank Dr. Orland E. White for helpful criticism and advice during the course of this study, and Mr. Robert C. Cook for kindly making photographs of the plants.



DIPLOID AND TETRAPLOID SEDUM PLANTS

Figure 8

A, plant of the tetraploid line 228 of *Sedum ternatum* photographed on May 3, 1936. On this date the diploid line was in full flower, whereas the tetraploid lines were just beginning to come into bloom. Below are shown a plant of the diploid line 64C on the right, and a plant of the tetraploid line on the left. This photograph was made on June 3. On this date the fruits of the diploid plants were mature and nearly dry while those of the tetraploid plants were still green. Tetraploid plants give an impression of being slightly larger than comparable diploids, but there is much overlapping between the diploid and the tetraploid strains in respect to size.

preparations (Figure 9*B*) the chromosomes are larger than in crystal-violet preparations (Figure 9*A*). The two drawings, however, may not be of strictly similar stages; the chromosomes in Figure 9*B* may not have reached maximum contraction. Constrictions are rendered more evident by the swelling of the chromosomes. In smears of root tips eight metaphasic chromosome-types can be identified; these types have been lettered *a-h* (Figure 9*B*). Type *b* is satellited. All of the types have median or submedian attachment constrictions. The meiotic chromosomes of the first and second metaphases in microsporogenesis are shown respectively in Figures 9*E* and 9 *F*. Eight bivalents are present. Meiosis is regular.

The other six lines are tetraploid. Each of them has thirty-two somatic chromosomes, medianly or submedianly constricted (Figure 9*C* and 9*D*). The chromosome-types of these lines were not ascertained. It is obvious, nevertheless, that in Figure 9*D* four chromosomes of the largest size are present. No satellites were observed. Though the drawing of first metaphase given here evidences sixteen bivalents and no multiple association of chromosomes (Figure 9*G*), such association is sometimes present. To demonstrate the types of associations seen at late metaphase or early anaphase of the first division three bivalents, two chains of three, and a ring of four are depicted in Figure 9*I*. These configurations were selected from different cells. The multiple associations give visible evidence of polyploidy, for it is assumed that a chromosomal association is the resultant of homologous chromosomes, or homologous parts of chromosomes, reciprocally attracted and chiasmaticly joined. Since the chromosomes in one of the chains differ in size from those in the other, the triplicate presence of two chromosome-types is patently demonstrated. Likewise, with reference to the ring, four chromosomes of a type are seen to be present; the bipartite structure of one of them is manifest. The polyploidy of these lines is also indicated by the grouped arrangement of the chromosomes at second metaphase (Figure 9*H*). Such arrangement, rather characteristic for some of the plants, may suggest either primary or secondary association. In other cases, the chromosomes at second metaphase are not so disposed (Figure 10), and sixteen of them may be counted without difficulty.

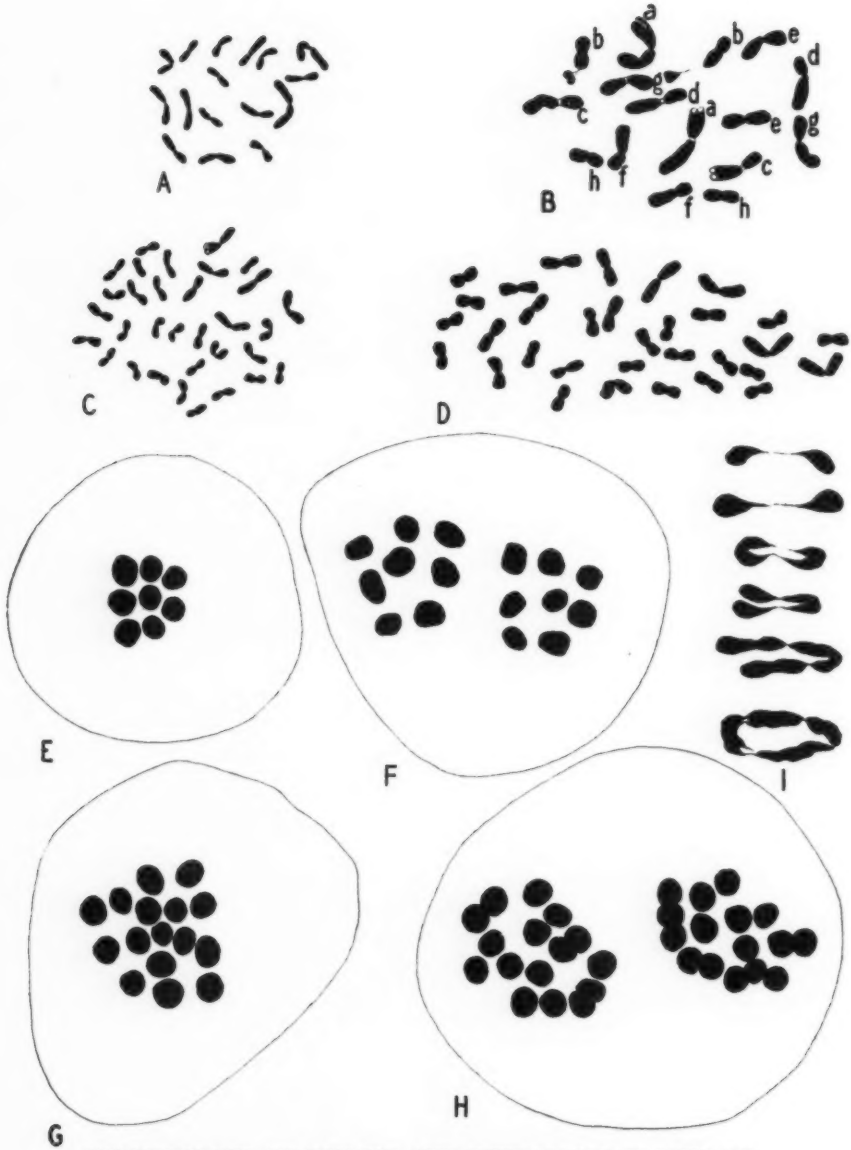
TABLE I. Source and Chromosome Number of Sedum ternatum investigated

Line	Source	n	2n
64C	Lewisburg, W. Va.	8	16
64A	Boyce, Va.	16	32
64B	Valley View Greenhouses	16	32
64D	Smoky Mountains, N. C.	16	32
138	Brooklyn Botanic Garden	16	32
226	Wytheville, Va		32
228	Asheville, N. C.		32

The tetraploid plants, in contrast to the diploid, produce some non-viable pollen. They vary with respect to the amount exhibited. Multiple association and consequent aberrant distribution of chromosomes may function in giving rise to defective pollen. But for Line 138, which consists of only one plant and which has a low percentage of good pollen, this explanation does not suffice. In this line, cell-wall formation between pollen mother-cells is often delayed or incompleted; the protoplasts are then connected by broad "plasmodesms." Such connections have been found at second metaphase (Figure 10). Cells so joined lie in more than one plane; those drawn here were pressed into the same plane in making the smear. The existence of these syndetic strands of protoplasm is probably the chief causative factor in the origin of the non-viable pollen. These strands, should they persist, would hinder mechanically the development of pollen. About 20 per cent of the tetrads in this plant are irregular. In Figure 11, one regular and five irregular tetrads are drawn.

In this species, as demonstrated by Figure 11, and in the genus, many contiguous pollen mother-cells are frequently observed at the same stage of division. Nor is it unusual for the plane of division to be the same in a number of those cells.

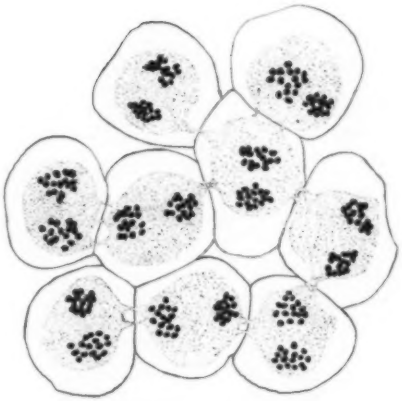
A significant difference in size exists



CHROMOSOMES OF DIPLOID AND TETRAPLOID PLANTS OF *SEDUM TERNATUM*

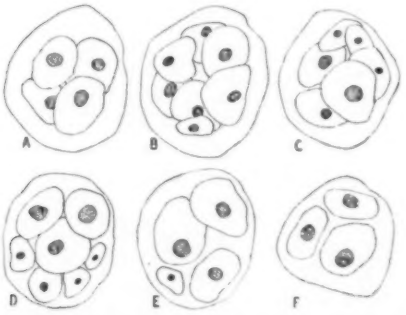
Figure 9

A and *C* are from crystal-violet preparations; *B*, *D*, *E*, *F*, *G*, *H*, and *I* are from aceto-carmine smears. All 3,200×. (*A*) Line 64C: $2n = 16$. (*B*) Line 64C: $2n = 16$. (*C*) Line 64D: $2n = 32$. (*D*) Line 64A: $2n = 32$. (*E*) Line 64C: First metaphase, $n = 8$. (*F*) Line 64C: Second metaphase, $n = 8$. (*G*) Line 138: First metaphase, $n = 16$. (*H*) Line 64B: Second metaphase, $n = 16$. (*I*) Line 64A: Metaphasic or anaphasic associations of chromosomes.



PROTOPLASMIC STRANDS
Figure 10

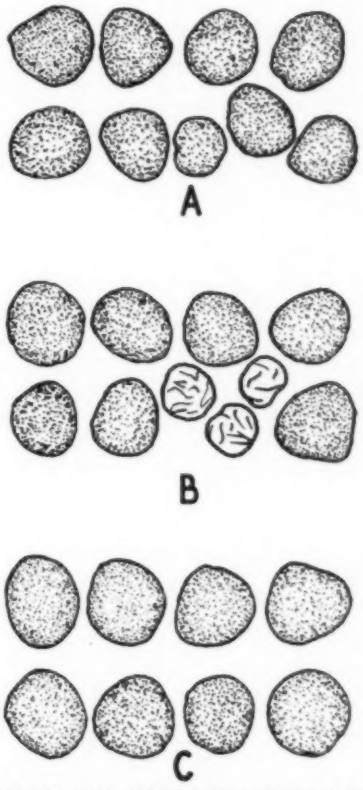
Strands of protoplasm connecting pollen mother-cells, Line 138 in which abortive pollen was noted. These persistant strands are probably a factor in the production of abortive pollen. Second metaphase, $n = 16$. Aceto-carmine smear, 875×.



"TETRADS" PRODUCED BY LINE 138
Figure 11

(A) Regular tetrad (B-F) Irregular. About 20 per cent of the tetrads produced in this line are irregular, this irregularity is associated in this line with the protoplasmic strands, and with the production of abortive pollen (Figure 12) 662×.

between the pollen mother-cells of the diploid and tetraploid plants. The pollen of the diploid is in general smaller. In aceto-carmine smears, however, the pollen of the diploid cannot be distinguished sharply from that of the tetraploid (Figure 12).



DIPLOID AND TETRAPLOID POLLEN
Figure 12

Shriveled pollen was observed rather frequently in the tetraploid forms but not in diploid. 480×. (A) Line 64C: Diploid; no shriveled pollen. (B) Line 138: Tetraploid; a high percentage of shriveled pollen. (C) Line 64A: Tetraploid; a low percentage of shriveled pollen.

Discussion

S. ternatum Michx. is a well defined species. It is seldom confused with other representatives of the family. Though its plants vary considerably in size, usually the differences are below the taxonomic level of a variety. One variety, however, var. *minus* Praeger, characterized by a constant dwarfness, has been established systematically for the species. The type specimen was found in culti-

SIMILARITIES AND DIFFERENCES OF DIPLOID AND TETRAPLOID SEDUM

Figure 13

"Head on" views of leaf rosettes at end of stems of tetraploid (upper row) and of diploid (second row) *Sedum ternatum*. No consistent difference in leaf size and shape has been noted. Below are shown fruit clusters of the two lines photographed on June 3, tetraploid above and diploid below. The tetraploid fruits are definitely larger than the diploid and they mature a few days later. Possibly the slightly greater vigor in growth is a factor in the occurrence of a much higher percentage of tetraploid plants in nature in the region in which the species has been studied.

vation in Europe. The diploid plants discussed in this paper fall within the scope of that varietal description. If the identification be correct, the variety, as Praeger[4] thought probable, is "an indigenous American form."

It is taxonomically certain that the seven lines of plants reported here belong to *S. ternatum*. The tetraploid lines are autopolyploid. The plants of these lines either arose as autotetraploids or, on the basis of a less plausible explanation, arose by the hybridization of diploid *ternatum* plants with members of a second species, the non-*ternatum* characters of the polyploid hybrid being subsequently eliminated by selection. Darlington has advanced these assumptions for comparable cases of polyploidy. The first assumption is for *S. ternatum* more tenable. *S. Nevii* A. Gray, the closest relative of *S. ternatum* in the same geographic area, has fourteen gametic chromosomes (Unpub.); this condition makes requisite a complex explanation if the assumption of origin of polyploidy by hybridization is to be accepted. Vegetative reproduction is pronounced in *S. ternatum;* a piece of stem in contact with a fitting substratum will generate a new individual. In conjunction with this capacity for asexual propagation, somatic doubling, a not unusual phenomenon in plants,—though it is not known for *S. ternatum*—would adequately account for the origin and preservation of polyploidy in the species. That six of the seven lines, or four of the five wild lines, are tetraploid is interesting and, perhaps, significant. This predominance suggests a demarcation of races. The tetraploid plants may survive better in the regions where they are found.

Intraspecific polyploidy in wild plants has been reported for comparatively few species. Darlington[3] includes a number of such plants in a list of intraspecific polyploids. He divides those species into two categories: those in which polyploidy is not associated with systematic differences, other than distribution, and those in which polyploidy is associated with slight systematic differences. The members of the second group have advanced further toward differentiation of new species. Forms resulting from autopolyploidy would not be expected at the time of their origin to differ markedly in appearance from the forms producing them. The rarity of records of polyploidy within uncultivated species does not of necessity mean rarity of its occurrence. Its cytological discovery may often in wild plants depend largely on chance.

In contrast to this chromosomal status infrequently reported for plants from the wild is the rather prevalent occurrence among cultivated plants of so-called intraspecific polyploidy. Forms so considered have, for example, been found for three cultivated species of *Sedum* (Unpub.). This discrepancy between cultivated and non-cultivated plants may be referable to several causes. Species assembled in cultivation render possible frequent opportunity for hybridization; reputed cases of polyploidy within species may in actuality be cases of allopolyploidy. Human selection gives rise to numerous, and often widely divergent, varieties, intra- as well as interspecific; they frequently differ in chromosome number. Polyploid forms sometimes have an economic value that is founded upon an increase in cell size. Because of that, though unwittingly, they are assiduously propagated. Cultivation recurringly affects the establishment of clons; non-sexual reproduction, whether controlled or natural, whether apomictic or purely vegetative, accumulates and transmits genic and chromosomal variations. Coincident with these conditions is the fact that material of cultivated plants is more easily obtainable, and therefore more readily available for study, than material of plants found only in nature.

The *n* number of chromosomes in *S. ternatum* is reported to be 8 and 16; 8 is haploid for the species. Other species of *Sedum* with *n* numbers of 6, 7, 8, 10, 11, 12, 13, 14, 16, 17, 18, 20, etc., have been investigated (Unpub.). No single chromosomal series has been operative in the evolution of the genus.

Summary

Taxonomically it is certain that the seven lines of plants discussed in this paper belong to *S. ternatum* Michx. Six of these lines are autotetraploid, one diploid. The diploid may be var. *minus* Praeger. The haploid number for the species is 8.

The diploid has eight types of chromosomes at mitotic metaphase. One of these types bears a satellite. The chromosome-types of the tetraploid were not determined. All the chromosomes of both the diploid and the tetraploid have median or submedian attachment constrictions.

Meiosis in the diploid is normal; eight bivalents are formed. Multivalents occur at first metaphase in the tetraploid; two chains of three and a ring of four are drawn. Chromosome groups resulting from either primary or secondary association are sometimes present at second metaphase.

The production by the tetraploid plants of some non-viable pollen is possibly correlated with multiple association and consequent aberrant distribution of chromosomes. One line often has broad strands of protoplasm connecting the pollen mother-cells; this line has a lower percentage of good pollen than do the other tetraploid lines. The two phenomena may hold a cause-effect relation.

In order that polyploidy in *S. ternatum* may be further investigated a request is made for contribution of specimens collected from the wild.

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THE ENDOCRINES IN REVIEW

THIS book* is a unique production. It is practically without text as such, but is composed of charts, diagrams and schematic drawings illustrating the structure, functions, chemical composition, inter-relationships and clinical applications of the various endocrine glands. The material is logically arranged in ten sections, is up to date, is clearly presented, and its scientific status is well evaluated and properly qualified.

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N. D. C. Lewis
Neurological Institute of New York

**A, B, C of the Endocrines.* By Jennie Gregory. Pp. xiii and 126. Baltimore, The Williams and Wilkins Co., 1935.

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